Cellular and PCS Network Measurements

Outputs

- Network discovery.
- Wireless network capacity and interference measurements.
- Hostile environment characterization.

The Federal Government is relying more heavily on commercial wireless infrastructure to satisfy its communications needs. Consequently, government services are increasingly dependent on commercial wireless infrastructure. In times of national emergency it is imperative to maintain a continuity of government service over these infrastructures so that critical government services are not interrupted. Therefore, it is crucial that the government have an understanding of the commercial networks that it is relying on.

In contrast to wired networks, wireless networks exhibit an ephemeral and dynamic relationship between services and resources. At each transaction, the measurable RF and network parameters will change depending on the demands of that particular transaction. It is essential to investigate both of these domains, radio and network, in order to understand the network behavior, since simple RF power measurements alone are inadequate.

Analysis of commercial wireless networks is achieved by collecting network protocol messages and physical RF link measurements. Both types of data are needed to identify wireless network characteristics such as usage patterns, channel resource allocation and network topology. This multifaceted viewpoint is necessary since many wireless network architectures rely on spread spectrum techniques to increase user density. Without this real time information about the air interface and the network interface, parameters like channel occupancy would not be obtainable. For instance, in IS-95 networks, the paging channel must be decoded to gain access to the Walsh code domain which is required to measure traffic channel activity. A similar problem exists in GSM networks, where frequency hopping sequences and time slot allocations from control channels are needed to identify user activity. These kinds of measurements are not possible without examining the integral connection between network protocols and radio resources. These tools are used to identify the intricacies of wireless infrastructure topologies in real time.

To help develop a better understanding of the loading of commercial wireless networks, ITS has conducted a series of IS-95 network code channel occupancy measurements. The code domain correlation strength data was collected over several time regimes. Both continuous and discrete measurements were made during potential busy hours and busy daytime periods. A statistical analysis of the IS-95 base station code channel occupancy was then conducted. Results of the analysis are shown in Figures 1 and 2, which show the channel occupancy and channel idle time distributions, respectively. The data in Figure 1 are suggestive of a lognormal distribution. Previous investigators have found that call holding distributions exhibit a lognormal

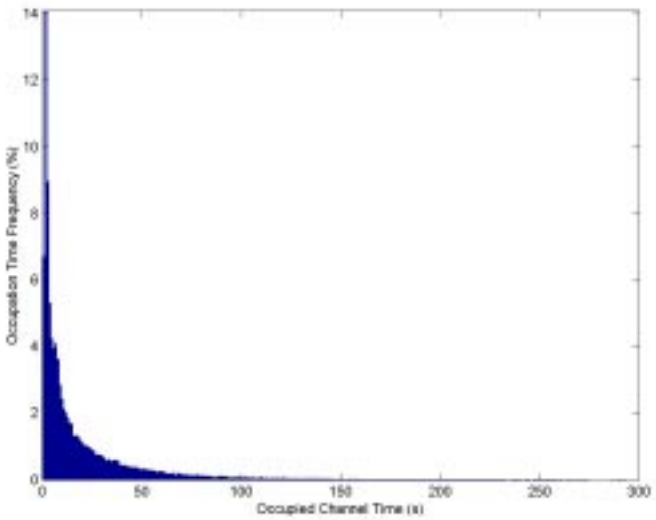

Figure 1. Occupied channel time distribution (discrete case).

characteristic.* This contrasts with the exponential distribution observed in wireline systems.

The second distribution, Figure 2, examines the time between successive uses of a code channel. Essentially, this is a look at the call arrival model, and shows that it too represents the lognormal distribution. In contrast to the occupancy, or channel holding-time model in the previous figure, this result was unexpected since previous investigators had found an exponential distribution for this statistic.* The discrepancy might be due to the abstracted nature of code power measurements versus true user occupancy data.

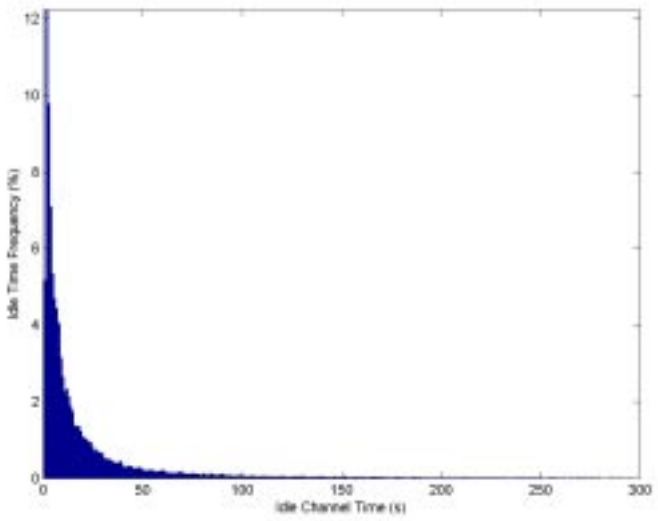

Figure 2. Unoccupied channel time distribution (discrete case).

Since there is very little public domain information available about real time cellular/PCS usage, this work will help in the development of usage pattern models for both commercial and government users. This kind of data has added benefit to Federal network planners in that it is an independent evaluation of commercial providers of government communication services.

Figure 3. Wireless phones used in cellular and PCS network measurements in the ITS Wireless Networks Research Center (photograph by S. Wolf).

ITS has also investigated issues relating to GSM interference. ITS has conducted a series of experiments that explore the behavior of GSM handsets in hostile environments. Such an interference environment would be expected to materialize in times of national emergency. Experiments attempted to identify user recognizable and measurable manifestations of system congestion or other manmade sources of interference. These tests were designed to help quickly identify network overload and vulnerabilities.

* C. Jedrzychi and V.C. M.Leung, "Probability of channel holding time in cellular telephony systems," in *Proc. 46th IEEE Vehicular Technology Conference, Mobile Technology for the Human Race*, Volume 2, 1996, pp 247-251.

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